HMA PRODUCTION MANUAL

October 2003

MDOT
Michigan Department of Transportation

CONSTRUCTION AND TECHNOLOGY
SUPPORT AREA

FOREWORD

This manual is the combination of three separate Hot Mix Asphalt (HMA) manuals used in the design, production, and testing of HMA for MDOT projects. These manuals were:

- The Procedures Manual for Mix Design Processing
- Manual for the Certification of Hot Mix Asphalt Plants
- HMA QC/QA Procedures Manual for Field Testing

These manuals will now be referred to by three separate sections in this HMA Production Manual.

Section 1: Procedures Manual for HMA Mix Design Processing

This section provides the mix design guidelines for Marshall and Superpave Hot Mix Asphalt mixtures for use on MDOT projects. Included are examples of calculations, documentation requirements and contact information for MDOT and private testing laboratories.

Section 2: Certification of Hot Mix Asphalt Plants

This section provides the requirements for certifying Hot Mix Asphalt Plants. The certification procedures are administered by the Lansing Construction & Technology Support Area, with direct support from the Region Traveling Mix Inspector. The requirements of these procedures do not replace or supercede MDOT specifications or other legal requirements referenced in this section.

Section 3: HMA QC/QA Procedures Manual of Field Testing

The checklists in this section are intended to provide a quick reference guide for the performance of Hot Mix Asphalt sampling and testing required by the MDOT Hot Mix Asphalt Quality Control/Quality Assurance Program. These checklists do not replace or supersede the referenced MDOT, AASHTO or ASTM test methods or quality assurance procedures. The user should insert the referenced test methods in this manual where indicated.

All requirements contained in this manual for Certification of Hot Mix Asphalt Plants and all MDOT quality assurance procedures will be reviewed and revised annually. Revisions will be distributed through the MDOT Publications Office. These sections are formatted to allow revised pages to be easily substituted. It may be necessary to retain superseded pages for reference on projects which have been advertised prior to the date revisions are implemented.

The values stated in either inch-pound units (English) or SI units (metric) are to be regarded as the standard; within the text and tables, metric units are shown in parentheses. The values stated in each system may not be exactly equivalent; therefore each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

MDOT Mission Statement:

Provide the highest quality transportation for economic benefit and improved quality of life.

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TABLE OF CONTENTS

SECTION 1: PROCEDURES FOR HMA MIX DESIGN PROCESSING

SECTION 2: CERTIFICATION PROCEDURE OF HOT MIX ASPHALT PLANTS

SECTION 3: HMA QC/QA PROCEDURES FOR FIELD TESTING

SECTION 1: PROCEDURES FOR HMA MIX DESIGN PROCESSING

HOT MIX ASPHALT (HMA) MIX DESIGN LABORATORY QUALIFICATIONS

To be qualified to submit HMA mix designs for projects with the Michigan Department of Transportation (MDOT) oversight the laboratory must meet the following criteria:

1. Demonstrate successful completion of the MDOT Superpave Mix Design Certification Course.

2. Current AASHTO Materials Reference Laboratory (AMRL) laboratory inspection with responses on file with the department.

   a. AMRL report must be a carbon copy from the AMRL.

   b. Responses to any deficiencies from the participating laboratory.

AASHTO Materials Reference Laboratory (AMRL) Laboratory Inspection

The following test procedures are required:

ASTM D2726/T166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
ASTM D2041/T209	Maximum Specific Gravity of Bituminous Paving Mixtures
ASTM D1559/T245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D3203/T269	Percent Air Voids in Compacted Dense & Open Bituminous Paving Mixtures
AASHTO T312	Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor

A copy of the AMRL inspection report is to be sent to:

Michigan Department of Transportation
Construction & Technology Support Area
Bituminous Mix Design Unit
P.O. Box 30050
Lansing, Michigan 48909

3. Participation in the AMRL Proficiency Sample Program (PSP) with results forwarded from the AMRL lab to MDOT, C&T - Lansing. The following sample participation is required.

    a. Hot Mix Asphalt Design (Hveem/Marshall)

    b. Hot Mix Asphalt Gyratory

    c. Coarse Aggregate

    d. Fine Aggregate

4. Contact information for Personnel responsible for signing mix designs from the laboratory on file with the department.

Laboratories applying for initial (probationary) qualification to submit HMA mix designs for department project will submit a packet containing the above information to the following address:

Michigan Department of Transportation
Construction & Technology Support Area
C/O Bituminous Mixtures and Materials Engineer
8885 Ricks Road
P.O. Box 30049
Lansing, MI 48909

Upon satisfying the requirements for qualifying to submit HMA mix designs for department projects, the design laboratory will receive written notification of their MDOT lab number and may commence submitting designs. There is no time frame for review or issuance of the approval to submit.

MARSHALL MIXTURE DESIGNS

1. Mix Design General Guidelines

For all projects, the Contractor will supply the Michigan Department of Transportation (MDOT) with a SUBMITTED MIX DESIGN (SMD). The SMD must be prepared by a private testing laboratory either the Contractor or consultant. SMD's must be prepared in accordance with MTM 322-97, Michigan Test Method for Bituminous Marshall Mix Design Procedure.

- When a Contractor uses a consulting laboratory to supply a mix design, the Contractor must authorize in writing that the consultant acts as the Contractor's agent on mix design issues for the project.

- MDOT will only accept one passing design per course, per project. The maximum number of designs per course, per project, that any one Contractor/consultant laboratory may submit is two.

Submittal of a submitted mix design shall be made to:

MDOT
Construction and Technology Laboratory
Bituminous Mix Design Unit
8885 Ricks Road
P.O. Box 30049
Lansing, Michigan 48909

Acceptance for evaluation requires a person from the Bituminous Mix Design Unit to review the paperwork and submitted material. Upon acceptance, MDOT will have five work days to evaluate the submitted mix design. SMD's received after 11.45 a.m. will start the five work day clock on the next scheduled work day.

Note: Work days are Monday through Friday excluding state holidays.

The Project Engineer may require a new mix design from the Contractor on materials at any time it is determined necessary.

2. Paper Review Acceptance Criteria

The Bituminous Mix Design Unit's evaluation of a paper review design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Mix Design data with MDOT's Bituminous Mix Design Computer Program.

Tolerance Limits for MDOT Paper Review:

Marshall

a. All data must meet specification.

b. Volume of compacted specimens: 515 cm^3 ± 8 cm^3.

c. Spread between 3 Marshall Gmb's at a given asphalt content within: 0.013.

d. Spread between Gse's on a 4-point design within: 0.012.

e. The flow value consistently increases with increasing asphalt content.

f. The percent of air voids steadily decreases with increasing asphalt content.

g. The VMA generally decreases to a minimum value, then increases with increasing asphalt content.

3. Submitted Mix Design

The Bituminous Mix Design Unit's evaluation of the submitted mix design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the submitted mix design data with MDOT's Bituminous Mix Design Computer Program.

At the department's discretion, any or all of the following testing may be performed.

Test the following physical properties of the recovered aggregate for compliance to specification:

- Aggregate Wear Index (AWI) - for top course material only
- Angularity Index (AI)
- Soft Stone
- Percent Crush
- Current Los Angeles Abrasion Number

Prepare Marshall specimens for testing stability and flow (ASTM 1559), bulk specific gravity (ASTM 2726).

Prepare specimens for maximum theoretical specific gravity (ASTM 2041).

Perform a sieve analysis (ASTM C136) and asphalt content on mixture submitted and compare results to the mix design and evaluation on:

- Aggregate gradation
- Percent crush
- Percent of recovered asphalt cement

4. Materials Required:

a. 1 - 5000 gram samples of mixture @ optimum asphalt content.

Note: At least 1 full test point (0.5 % asphalt) above or below optimum asphalt content is required. Identify on Form 1813 the asphalt content of submitted mix.

b. Individual Aggregate Wear Index (AWI) samples for each aggregate requiring an AWI value.

Note: This should be submitted even if a nomograph exists for that aggregate.

5. Documentation Required:

Form 1820 - Contractor Bituminous Mix Design Communication.

Form 1923 - Sample Identification. **Note**: must be included in each sample package.

Form 1813 - Submitted Mix Design Summary Sheet.

Form 1822 - Marshall Mix Design Work Sheet.

Form 1806 - Theoretical Maximum Specific Gravity.

Form 1849 - Bituminous Mix Design Checklist.

Form 1859 - Coarse Aggregate Gravity.

Form 1860 - Fine Aggregate Gravity.

Form 1879 - RAP Stockpile Summary Data Sheet. **Note:** only if RAP is included in the mixture.

Combined gradation plotted on a 0.45 Power Gradation chart.

Mix Design Regression Analysis.

Temperature - Viscosity Graph/Table showing mixing and compaction temperatures.

Note: Current MDOT forms are required on the mix design submittal. If you make a computer copy, it must match the MDOT form exactly. If these forms are not used, the mix design verification process will be stopped until the correct forms are submitted.

6. Tolerance Limits* for MDOT Verification of Submitted Mix Designs

Bulk specific gravity of mixture ± 0.026.

Theoretical maximum specific gravity ± 0.019.

Air voids ± 1.00.

Asphalt content ± 0.3%.

% crush must meet specification for project.

Verification tolerance for crush particle content ± 15%.

Angularity index must meet specification for project.

Stability must meet specification for project.

Flow must meet specification for project.

Aggregate gradation must meet design master gradation specification.

Sieve 1 inch (25.0 mm) thru ⅜ inch (9.50 mm) ± 3.0%.

Sieve No. 4 (4.75 mm) thru No. 50 (0.30 mm) ± 2.0%.

Sieve No. 100 (0.15 mm) thru No. 200 (0.075 mm) ± 1.0%.

Fine aggregate bulk-SSD-apparent specific gravity ± 0.028.

Coarse aggregate bulk-SSD-apparent specific gravity ± 0.028.

Final aggregate blend bulk - SSD - apparent specific gravity ± 0.028.

*SMD's that meet all tolerance limits will be reported out as passing.

7. Submitted Mix Design Time Period (Five Work Days)

MDOT will have five (5) work days in which to review the submitted mix design.

The five (5) work day time period begins when the mix design submittal forms and materials are deemed to be complete and correct by the Bituminous Mix Design Unit.

The mix design may be refused, or the review and the five (5) work day time period stopped, for the following situations (but not limited to):

a. Evaluation of mix design results indicate a failing design.

b. Incorrect or insufficient material is submitted.

c. Aggregate(s) do not meet physical requirements specified for the project.

d. The Contractor-requested combined gradation does not meet Master Gradation Range in the applicable Standard Specifications or Special Provision.

e. No project office notification.

f. Incomplete documentation.

g. Lacks a current Los Angeles Abrasion Number.

h. Contractor suspends interest in submitted material.

Restart of the five (5) work day clock will commence upon the timely response by the Contractor in efforts to resolve any discrepancies in the submittal.

The Contractor, Traveling Mix Inspector and/or the Project Engineer will be notified of situations that require cancellation of a Bituminous Mix Design submittal for reasons such as those listed above.

8. Resubmittals

If your mix design fails and you wish to resubmit. The maximum number of mix designs per course, per project, that any one Contractor/consultant laboratory may submit is two (2). Follow the requirements below:

MARSHALL MIX DESIGN

Fails on	**Submit**
Gmb	1 - 5000 gram mixture samples Complete paperwork
Gmm	1 - 5000 gram mixture samples Complete paperwork
Air Voids	1 - 5000 gram mixture samples Complete paperwork
Asphalt Content, Gradation, Crush	1 - 5000 gram mixture samples Complete paperwork
Angularity Index	Redesign Complete paperwork
Stability & Flow	Redesign Complete paperwork
AWI	Redesign Complete paperwork

SUPERPAVE MIXTURE DESIGN

1. Superpave Mix Design General Guidelines

For all projects containing the Special Provision for Superpave Bituminous Mixtures, the Contractor will supply the Michigan Department of Transportation's Superpave Mix Design. The Superpave Mix Design must be prepared by a private testing laboratory, either the Contractor or consultant. Superpave Mix Designs must be prepared in accordance with the SUPERPAVE MIX DESIGN MANUAL (SP-2)*.

If a Contractor uses a consulting laboratory to supply a mix design, the Contractor must authorize in writing that the consultant acts as the Contractor's agent on mix design issues for the project. MDOT will only accept one passing design per course, per project. The maximum number of designs per course, per project, that any one Contractor/consultant laboratory may submit is two.

Submittal of a Superpave Mix Design shall be made to:

MDOT
Construction and Technology Laboratory
Bituminous Mix Design Unit
8885 Ricks Road
P.O. Box 30049
Lansing, Michigan 48909

Acceptance for evaluation requires a person from the Bituminous Mix Design Unit to review the paperwork and the submitted material. Upon acceptance, MDOT will have 10 work days to evaluate the Superpave Mix Design. Superpave Mix Designs received after 11:45 a.m. will start the 10 day work clock on the next scheduled work day.

Note: Work days are Monday through Friday excluding state holidays.

The Project Engineer may require a new mix design from the Contractor on materials at any time it is determined necessary.

*****Superpave Mix Design, Superpave Series No. 2 (SP-2). Asphalt Institute, Research Park Drive, P.O. Box 14052, Lexington, Kentucky 40512-4052.

SUPERPAVE COMPARISON LEVEL DESIGN SUBMITTAL

1. Paper Review Acceptance Criteria

The Bituminous Mix Design Unit's evaluation of a paper review design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Mix Design data with MDOT's Bituminous Mix Design Computer Program.

Tolerance Limits for MDOT Paper Review:

Superpave

a. All data must meet specification.

b. Height of a compacted gyratory specimen: 115 mm ± 3 mm.

c. Spread between 2 gyratory Gmb's at a given asphalt content within: 0.012.

d. Spread between Gse's on a 4 point design within: 0.012.

e. The percent of air voids steadily decreases with increasing asphalt content.

f. The VMA plotted values generally decrease to a minimum value then increase with increasing asphalt content.

2. Superpave Mix Design

The Bituminous Mix Design Unit's evaluation of the Superpave Mix Design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Superpave Mix Design data with MDOT's Bituminous Mix Design Computer Program.

Test the following physical properties of the aggregate for compliance to specification:

- Aggregate Wear Index (AWI) - for top course material only.
- Angularity Index (NAA Method A).
- Flat and elongated particles.
- Percent crush (½ sides).
- Current Los Angeles Abrasion number.
- Fine Aggregate Bulk - SSD - apparent specific gravities and % absorption.
- Coarse Aggregate Bulk - SSD - apparent specific gravities and % absorption.

- Sand equivalent of fine aggregate (ASTM D 2419).
- % Soft Particles.

Prepare gyratory specimens per Superpave Mix Design Manual (SP-2) for bulk specific gravity (ASTM 2726).

Prepare specimens for maximum theoretical specific gravity (ASTM 2041).

Perform a gradation and asphalt analysis on mixture submitted and compare results to the Superpave Mix Design and evaluation on:

- Aggregate gradation.
- Percent crush.
- Percent of recovered asphalt cement.

3. Tensile Strength Ratio (TSR)

On Superpave Mix Designs, the Contractor and/or consultant will perform the TSR testing for the design. The Contractor and/or consultant certify that the TSR meets specification. If the design requires an anti-strip agent to be added, the type and percent added will be stated on the mix design submittal. All test results will be submitted to MDOT with the design submittal.

During production, a mixture sample will be taken by MDOT. This sample will be submitted and tested at the Bituminous Mix Design Laboratory in Lansing, Michigan.

If the MDOT TSR testing meets project specifications, a report of test is sent to the project office showing the results. If the MDOT test results fail to meet specification, the following applies:

a. The Project Engineer will be notified and a sufficient amount of anti-strip agent will be added to the mixture.

b. The next mix design submitted by the Contractor/consultant will require the submission of TSR samples for verification/acceptance testing. Subsequent mix design submitted will not be reported out until verification/acceptance of the TSR testing is complete.

4. Materials Required:

Note: All mixture samples are submitted at optimum asphalt content.

3- *gram samples of mixture.
(Gyratory Compaction)
Note: At least one full test point (0.5% asphalt) above or below optimum asphalt content is required.

2 - 1500 gram samples of mixture.
(Virgin Mix Design Only) (Extraction - Asphalt Ignition Oven).

2 - 1900 gram samples of mixture.
(Rap Mix Design Only) (Extraction).

2 - 1400 gram samples of blended aggregate.
(Virgin Mix Design Only) (Calibration of the Asphalt Ignition Oven).

1 - 190 gram sample blended angularity index.
(N.A.A. Method A) (Washed & Dried).

Individual aggregate wear index (AWI) samples for each aggregate which requires an AWI value.

Note: these should be submitted even if a nomograph exists for that aggregate or if previously submitted on another design.

1 - 2000 gram sample of blended aggregate, retained No. 4 (4.75 mm) sieve.
(Washed & Dried)(Coarse Aggregate Specific Gravity).

1 - 1400 gram sample of blended aggregate, passing No. 8 (2.36 mm) sieve.
(Washed & Dried)(Fine Aggregate Specific Gravity).

1 - 2000 gram sample of aggregate retained No. 8 (2.36 mm) sieve.
(Washed & Dried)(Aggregate Specific Gravity).
Note: only if 25% or greater is retained on the No. 8 (2.36 mm) sieve.

1 - 1400 gram sample of blended aggregate, passing No. 4 (4.75 mm) sieve.
(Not washed)(Sand Equivalent Test).

***** The weight of the mix to compact to 115 mm height at Nmax.

5. Documentation Required:

Form 1855 - Superpave Bituminous Mix Design Communication.

Form 1923 - Sample Identification. **Note:** Must be included in each sample package.

Form 1858 - Superpave Mix Design Summary Sheet.

Form 1806 - Theoretical Maximum Specific Gravity worksheet.

Form 1851 - Gyratory Compacted Bulk Specific Gravity Worksheet.

Form 1859 - Coarse Aggregate Gravity

Form 1860 - Fine Aggregate Gravity

Form 1862 - Superpave Mix Design Checklist.

Form 1879 - RAP Stockpile Summary Data Sheet

Combined gradation plotted on a 0.45 Power Gradation chart.

Mix Design Regression Analysis.

Summary Height Data @ N_{ini}, N_{des}, and $N_{max.}$ For each, replicate at all asphalt contents.

Form 1937 - TSR Worksheet including Graphs from Testing

Temperature - Viscosity Graph/Table showing mixing and compaction temperatures

Note: Current MDOT forms are required on the mix design submittal. If you make a computer copy, it must match the MDOT form exactly. If these forms are not used, the mix design verification process will be stopped until the correct forms are submitted.

6. Tolerance Limits for MDOT Verification of Superpave Mix Designs:

Compacted bulk specific gravity of mixture ± 0.020.

Theoretical maximum specific gravity ± 0.013.

Air voids ± 1.00.

Asphalt content ± 0.3%.

% crush must meet specification for project.

Verification tolerance for crush particle content ± 15%.

Angularity index must meet specification for project.

Aggregate gradation must meet design master gradation specification.

Sieve 1 inch (25.0 mm) through ⅜ inch (9.50 mm) ± 3.0%.

Sieve No. 4 (4.75 mm) through No. 50 (300 μm) ± 2.0%.

Sieve No. 100 (150 μm) through No. 200 (75 μm) ± 1.0%.

The tensile strength ratio must meet a minimum 80%.

Sand equivalent test results must meet specification.

MDOT gyratory test results must meet all project specifications.

7. Superpave Mix Design Time Period (Ten Work Days)

MDOT will have 10 work days to review the Superpave Mix Design.

The 10 work day time period begins when the Superpave Mix Design submittal forms and materials are deemed to be complete and correct by the Bituminous Mix Design Unit.

The Superpave Mix Design may be refused, or the review and the 10 work day time period stopped, for the following situations (but not limited to):

a. Evaluation of Superpave Mix Design results indicates a failing design.

b. Incorrect or insufficient material is submitted.

c. Incomplete documentation.

d. Aggregate(s) do not meet physical requirements specified for the project.

e. The Contractor requested combined gradation does not meet Table 10 Aggregate Gradation Requirements of the Special Provision for Superpave Bituminous Mixtures.

f. No project office notification.

g. Lacks a current Los Angeles Abrasion Number.

h. Contractor suspends interest in submitted material.

Re-start of the 10 work day clock will commence upon the timely response by the Contractor in efforts to resolve any discrepancies in the submittal.

The Contractor/consultant, Traveling Mix Inspector and/or the Project Engineer will be notified of situations requiring cancellation of a Superpave Mix Design submittal for reasons such as those listed above.

8. Resubmittals

If your mix design fails and you wish to resubmit. The maximum number of mix designs per course, per project, that any one Contractor/consultant laboratory may submit is two (2). Follow the requirements below:

SUPERPAVE MIX DESIGN

Fails on	**Submit**
Gmb	3- * gram sample of mixture Complete paperwork
Gmm	3- * gram sample of mixture Complete paperwork

Air Voids	3- * gram samples of mixture Complete paperwork
Asphalt Content, Gradation, Crush	3- * gram samples of mixture Complete paperwork
Angularity Index	Redesign Complete paperwork
AWI	Redesign Complete paperwork
Fine, No. 8 (2.36 mm), Coarse aggregate bulk specific gravities	Resubmit bulk aggregate samples Complete paperwork

***** The weight of the mix to compact to 115 mm height @ Nmax

Note: On failing mix designs, MDOT will tell the Contractor/consultant the tests(s) the design failed on. MDOT will not state the + or - tolerance of the failure.

SUPERPAVE EXPRESS MIX DESIGN SUBMITTAL PROCEDURE

1. Qualifying Laboratories – Superpave Express Designs

Laboratories applying for Express Superpave Mix Design Status must meet all the requirements in section 1 Qualifying Mix Design Labs and the following.

a. Previous and satisfactory Mix Design Experience with MDOT.

Laboratories requesting approval for Superpave express level submittals will have to put this request in writing to the MDOT Bituminous Engineer. Each request will be reviewed for compliance to the above criteria and previous mix design verification performance. Acceptance into the Superpave express level submittals program is judged at the agencies discretion.

2. Superpave Express Mix Design Submittal Paperwork

a. Paperwork Required on Express Superpave Mix Design Submittal's is the same as that for the comparison level Superpave mix design submittal package. A note should be made on the remarks page for Form 1855 Contractor's Superpave Bituminous Mix Design Communication Sheet noting that this is for Express Superpave Mix Design.

3. Materials Required for Express Superpave Mix Design Submittals

a. 3- * gram sample of mixture @ opt. A.C.[1]

b. AWI samples per Procedures Manual/BOH-IM 2003-01 if used on top course.

4. Submittal Time Frame

a. Design will be reviewed and verified within 5 working days after the date of sample login. Therefore the 5 work day period will start the day after sample receipt.

b. Designs Submitted for Top Course use are exempt from this time frame constraint until the necessary AWI Samples are processed.

c. The 5 work day time period may be stopped for all reasons listed in item 7, page 13, but not limited to.

5. Program Management

a. Initial eligibility for the program will be through written notification to the mix designer applying for Superpave Express Submittal Status Consideration. This will be through Certified mail return receipt requested.

b. Removal from the Superpave Express Submittal Status will be through written notification to the mix designer by certified mail return receipt requested.

[1] * = Grams of mixture to achieve 115mm $\pm$ 3mm height @ N_{max}

i. Causes for removal from Superpave Express Submittal Status

a. Repeated submission of designs with non-compliant and/or incorrect data.

b. Repeated offenses of designs with non-conforming samples or sample submittals.

ii. Comparison level design submittal will still be allowed for labs that are removed from Superpave Express Submittal Status.

c. Reinstatement of Superpave Express Submittal Status will be considered after enough comparison Superpave level design submittals have been reviewed to invoke agency confidence in the mix designer. However the mix designer will have to request reinstatement in writing through the MDOT Bituminous Engineer.

CALCULATIONS

1. Marshall Volumes

The MS-2 Manual[1] recommends that the correct size of a compacted 4 inch Marshall is 63.5 mm ± 1.27 mm. This is equivalent to a volume of 515 ± 8. If the Marshall height or volume falls outside the limits, the amount of mixture used for the specimen may be adjusted using:

$$\text{Adjusted weight of mix} = \frac{515 * \text{weight of mix used}}{\text{volume measured}}$$

a. Mix Design Methods for Asphalt Concrete (MS-2), Asphalt Institute, Research Park Drive, P.O. Box 14052 Lexington, KY 40512-4052.

2. Gyratory Sample Heights

The correct height of a compacted gyratory sample at N max is 115 mm ± 3 mm. If the gyratory sample height falls outside the limits, the amount of mixture used for the sample may be adjusted, using:

$$\text{Adjusted weight of mix} = \frac{115 * \text{weight of mix used}}{\text{height measured}}$$

For the mixture samples submitted at optimum asphalt content for gyratory compaction. Adjust the submittal weight so MDOT compacts to a 115 mm height at N max.

3. Mix Designs with Reclaimed Asphalt Pavement (RAP)

The Contractor may substitute Reclaimed Asphalt Pavement (RAP) for a portion of the new materials required to produce bituminous mixture for a project. The mixture shall be produced in accordance with Section 501 of the applicable Standard Specifications, or as modified herein.

Documented evidence of testing and accumulated tonnage in the stockpile (tonnage may be estimated) must be provided to the MDOT Construction and Technology Laboratory before a mix design will be processed. Use MDOT form, see appendix.

When RAP is used in a mix design, in which the Angularity Index (NAA Method A) and VMA are calculated from the aggregate bulk specific gravity, the following procedure applies. The RAP Gse is converted to a bulk aggregate specific gravity Gsb using the following formula:

$$\text{RAP Gsb} = (1.097 * \text{RAP Gse}) - 0.32$$

This Gsb represents both the fine and coarse aggregate bulk specific gravities for the RAP, from which the combine bulk aggregate gravity for the blend is calculated.

Example: The average Gse on a RAP stockpile is 2.695. The RAP Gsb is:

RAP Gsb = (1.097 * 2.695) - 0.32
RAP Gsb = 2.956 - 0.32
RAP Gsb = 2.636

CALCULATION OF THE VIRGIN AGGREGATE COMBINED GRADATION FOR MIX DESIGNS WITH RAP

Combined Gradation with RAP

PIT NUMBER TYPE OF AGGREGATE	RAP	95-5 ⅜ CLEAR	41-117 ⅜ - 4	41-117 No.4-0	95-5 DOLOMITE SAND	COMBINED GRADATION
PERCENT OF	20.0	20.0	18.0	25.0	17.0	
19.0 mm	100.	100.0	100.0	100.0	100.0	100.0
12.5 mm	99.0	98.8	100.0	100.0	100.0	99.6
9.5 mm	75.0	62.3	99.8	100.0	100.0	87.4
4.75 mm	56.0	7.1	11.9	89.5	93.4	53.0
2.36 mm	32.0	4.3	3.0	56.8	37.1	28.3
1.18 mm	21.0	3.5	2.1	34.9	22.5	17.8
600 μm	17.0	2.8	1.7	22.6	16.7	12.8
300 μm	14.0	2.3	1.5	13.3	13.0	9.1
150 μm	11.0	2.0	1.3	6.3	8.7	5.9
75 μm	7.6	1.5	1.1	4.0	5.0	3.9
Crush, Ret. No. 4	100.	100.0	86.4	84.3	100.0	95

To obtain a combined gradation without the RAP, use the following formula to calculate each of the virgin aggregate adjusted percentages.

$$\text{Virgin aggregate adjusted percentage} = \frac{\text{(mix design virgin aggregate percentage from mix design)}}{\text{((100-RAP percentage) / 100))}}$$

Example for ⅜ - 4 aggregate from Pit 41-117:

(18) / ((100-20) / 100)) = 18 / .80

= 22.5%

Using the individual virgin aggregate adjusted percentages, and the respective aggregate stockpile gradations, compute the blended combined gradation of the belt sample.

Combined Gradation of the Belt Sample

PIT NUMBER TYPE OF AGGREGATE	RAP	95-5 ⅜ CLEAR	41-117 ⅜ - 4	41-117 No.4- 0	95-5 DOLOMIT E	COMBINED GRADATION
PERCENT OF		25.0	22.5	31.25	21.25	
19.0 mm	100.0	100.0	100.0	100.0	100.0	100.0
12.5 mm	99.0	98.8	100.0	100.0	100.0	99.7
9.5 mm	75.0	62.3	99.8	100.0	100.0	90.5
4.75 mm	56.0	7.1	11.9	89.5	93.4	52.3
2.36 mm	32.0	4.3	3.0	56.8	37.1	27.4
1.18 mm	21.0	3.5	2.1	34.9	22.5	17.0
600 μm	17.0	2.8	1.7	22.6	16.7	11.7
300 μm	14.0	2.3	1.5	13.3	13.0	7.8
150 μm	11.0	2.0	1.3	6.3	8.7	4.6
75 μm	7.6	1.5	1.1	4.0	5.0	2.9
Crush, Ret. No. 4	100.0	100.0	86.4	84.3	100.0	93

4. Bulk Aggregate Specific Gravities

The formula for combining the coarse, No. 8 and fine bulk specific gravities is as follows:

$$Combined\ Gsb = \frac{P_1 + P_2 + ... + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + ... + \frac{P_n}{G_n}}$$

where:

Gsb = bulk specific gravity
P_1, P_2, P_n = individual percentages by mass of aggregate
G_1, G_2, G_n = individual bulk specific gravities of aggregate

Example #1 Virgin Mix

Combined Coarse Gsb = 2.670
Combined No. 8 Gsb = 2.688
Combined Fine Gsb = 2.620

Combined Gradation: <u>% Passing</u>

4.75 mm sieve 71%
2.36 mm sieve 40 %

$$Combined\ Gsb = \frac{29 + 31 + 40}{\frac{29}{2.670} + \frac{31}{2.688} + ... + \frac{40}{2.620}} = 2.655$$

If less than 25% retained on the No. 8 Sieve. Show Calculation for combining fine & coarse.

Example #2 RAP Mix

Virgin Fine Combined Gsb = 2.676
Virgin Coarse Combined Gsb = 2.702
RAP Gsb = 2.715

Combined Gradation of Mix:	% Passing
4.75 mm sieve	37%
2.36 mm sieve	23%

Gradation of RAP	% Passing	Percent of Mix
2.36 mm sieve	56.6%	15%

Combined Virgin Fine & RAP Gsb:

56.6 * .15 = 8.5%

23-8.5 = 14.5%

8.5/.23 = 37%

14.5/.23 = 63.0%

$$\frac{37+63}{\frac{37}{2.715}+\frac{63}{2.676}} = 2.690$$

Combined Virgin Coarse & RAP Gsb:

43.4 * .15 = 6.5%

77-6.5 = 70.5%

6.5/.77 = 8.4%

70.5/.77 = 91.6%

$$\frac{8.4+91.6}{\frac{8.4}{2.715}+\frac{91.6}{2.702}} = 2.703$$

Combined Gsb =

$$\frac{23+77}{\frac{23}{2.690}+\frac{77}{2.703}} = 2.700$$

5. Tensile Strength Ratio (TSR) Samples

When submitting TSR data, you need to submit a worksheet showing compacted bulk specific gravity calculations, TMD at Opt. A.C., percent air voids and height of the TSR sample and completed work sheet.

Example:

Sample #	Wt in Air	SSD Wt.	Wt. in Water	Volume of Sample	Specific Gravity	TMD	Air Voids	Height of Sample

How to calculate the right sample size to achieve 95 mm height at 7 percent air voids:

- A good starting point is about 3800 to 3900 grams of mix and compact it to 95 mm height.
- Bulk sample out and calculate air voids.
- Make adjustments from first sample.

Example:

Sample #	Wt in Air	SSD Wt.	Wt. in Water	Volume of Sample	Specific Gravity	TMD	Air Voids	Height of Sample
1	3863	3883	2256.5	1626.5	2.375	2.516	5.6	95

At what height did you achieve 7 percent air voids? A quick check is to take this formula and keep trying different heights.

$\frac{X}{Y}$ * Original G_{mb} $\qquad\qquad$ $\frac{95.0}{96.4}$ * 2.375 = 2.340

X = height at last gyration
Y = height at any gyration $\qquad\qquad$ Air voids = 7.0%

Once you have found the height at which you achieved 7 percent air voids you can substitute the mass of the sample in for the G_{mb}.

$\frac{X}{Y}$ * Mass of Original Sample $\qquad\qquad$ $\frac{95.0}{96.4}$ * 3863.0 = 3806.7

A 3807 gram sample should give you a 95 mm TSR sample at 7 percent air voids ± 1 percent.

Highlights of the TSR test. (AASHTO DESIGNATION T 283)

- Preparation of the samples

    - Mix mixture and cool at room temperature for two hours ± 0.5 hours.
    - Place mixture in oven at 140 °F (60 °C) for 16 hours of curing.
    - After curing, place mixture in oven at 275 °F (135 °C) for two hours prior to compaction.
    - Compact mixture to 95 mm height.

- Conditioning of specimens

    - Three specimens will be stored at room temperature until testing.
    - At testing time they will be placed in a leak proof plastic bag and placed in a 77 °F (25 °C) water bath for minimum of two hours.
    - The other three specimens will be vacuum saturated so that 55% to 80% of original air voids are filled with water.
    - If samples are less than 55% saturated, put back under vacuum until at least 55% is obtained.
    - If specimens are greater than 80% saturated, must discard specimens and compact new ones.
    - Once 55% to 80% is reached, wrap in plastic film, place in plastic bag with 10 mL water and place in freezer at 0 ± 5 °F (-18 ± 3 °C) for a minimum of 16 hours.
    - After removal from freezer, place specimens in water bath at 140 ± 1.8 °F (60 ± 1 °C) for 24 ± 1 hours. As soon as possible remove plastic bag and film.
    - After 140 °F (60 °C) water bath, transfer specimens to a 77 ± 1 °F (25 ± 0.5 °C) water bath for 2 ± 1 hours.

- Testing of specimens

    - Remove from 77 °F (25 °C) water bath and place between to bearing plates.
    - Apply load to specimens by means of constant rate movement, 2 inches (50 mm) per minute.
    - Record maximum compressive strength.

- Calculations

    - If steel loading strips are used, calculate the tensile strength as follows:

$$S_t = \frac{2P}{\Pi tD}$$

Where:

S_t = tensile strength, psi (Pa),
P = maximum load, pounds (Newton),
t = specimen thickness, inches (mm),
D = specimen diameter, inches (mm)

    - Take the average tensile strength of the three conditioned specimens and divide by the average of the three unconditioned specimens. The ratio has to be a minimum of 80%.

AGGREGATE REQUIREMENTS

1. New Aggregate Source

If the aggregate source is new, the Contractor must submit to the District Materials Unit a legal description for the new source and directions for driving to the location so a pit number may be assigned.

2. Los Angeles Abrasion Number

Los Angeles Abrasions values are required on all new and existing aggregate sources. A Los Angeles Abrasion test is required if the percent retained on the No. 4 (4.75 mm) sieve is greater than 10 percent, or the percent retained on the No. 8 (2.36 mm) sieve is greater than 35 percent. An aggregate source with an L.A. Abrasion value lower than 35 is valid for 5 years, provided there are 3 L.A.s at 35 or under on record. If an aggregate source has an L.A. Abrasion value over 35, a minimum of one per year is required. If an L.A. Abrasion is required, contact your District Office to take the sample for submission to the Lab.

3. AWI Samples - BOH-IM 2003-01 and BOH-IM 2003-09

For each aggregate requiring an AWI number, the following procedure applies. Start with a 2500 gram sample and separate the retained No. 4 (4.75 mm), ⅜ inch (9.50 mm), and ½ inch (12.5 mm) aggregate by sieving. Wash each sieve size and dry. For each sieve size count out 300 particles and place in a small bag.

Note: Depending upon the gradation of the aggregate, a 300 particle count may not be possible.

In both cases, count the particles and place in a small bag and write the count and sieve size on the outside of the bag. For each aggregate put all the individual sieve size bags into a larger bag and include Form 1923 and Form 1820 completely filled out..

4. 10% Minimum Aggregate Requirement

No less than 10 percent of any single aggregate is allowed in the mix design, excluding mineral filler or baghouse fines. With written permission from the Project Engineer or the traveling mix inspector, less that 10 percent of single aggregate may be allowed. The written permission must be included with the mix design submittal.

5. Superpave Fine Aggregate Angularity

Fine aggregate angularity will be tested per Test Method for Uncompacted Void Content of fine Aggregate, ASTM C 1252, Method A. All aggregates including RAP which have material retained on the No. 16 (1.18 mm), No. 30 (600 μm), No. 50 (300 μm) and No. 100 (150 μm) are to be used in the blend.

Note: The RAP sample can be the result of either an extraction or asphalt ignition oven. For calculations, the GSE of the RAP is to be used. For virgin aggregates the bulk aggregate gravity will be used.

6. Aggregate Bulk Specific Gravities

Verification testing will be preformed on the combined blend. If the aggregate gradation meets the conditions stated below, the Contractor/consultant is required to record the test values for MDOT verification. Gsb for each aggregate should be performed if that aggregate meets the conditions stated below:

a. Coarse bulk gravity on each individual aggregate that retains ≥25% on the No. 4 (4.75 mm) sieve.

b. No. 8 bulk gravity on each individual aggregate that retains ≥25% on the No. 8 (2.36 mm) sieve.

c. Fine bulk gravity on each individual aggregate that has ≥25 passing the No. 8 (2.36 mm) sieve.

You will have a ± 0.028 tolerance on the combined bulk specific gravity.

7. Soft Particle Content

The Contractor/consultant will conduct the testing to insure that the soft particle content of the blended aggregate meets minimum specifications. MDOT will conduct a soft particle content on one of the submitted samples for verification to specification.

A sample may be taken (requested by the mix design unit) by MDOT during the project plant production of the mixture. The soft particle content will then be tested. If the soft particle content fails to meet the specification criteria, the Project Engineer will be contacted.

8. Sand Equivalent

The sand equivalent test will be tested by aggregate source. One test per source at five year intervals. Quarry and slag sources are excluded.

Before a mix design is submitted, the Contractor/consultant will call a designated source in the Bituminous Mix Design Laboratory to check if a sand equivalent sample needs to be submitted for an aggregate source. At the end of the construction season, the sand equivalent test results for each aggregate source will be published.

If one of the aggregate sources in the blend has a failing sand equivalent value, the combined aggregate blend is required for verification testing.

9. Nomograph

If a nomograph exists for an aggregate which requires an AWI value, the AWI number from the nomograph will be used for the mix design. An aggregate sample should still be submitted so the nomographs may be updated on a yearly basis.

CONTACT INFORMATION

1. **Contacts** - See Website for current list of contacts.

Grant Carr Mixture Testing	517-322-5691
Steve Zambrowski Aggregate Bulk Gravity - TSR's Submission of Marshall and Superpave Mix Designs Sand Equivalent Test	517-322-5293
Victor Prewitt Status of newly submitted Los Angeles Abrasion Test results	517-322-1219
Alan Robords Assigning pit numbers - AWI's - Nomographs - Existing Los Angeles Abrasion Numbers	517-322-1357
Marc Beyer Traveling Mix Inspectors (TMI) Plant certification 1911's	517-322-1020

If you need a copy of a mix design, contact your Region TMI and they will request it from Bituminous Mix Design Unit.

SECTION 2: CERTIFICATION PROCEDURE OF HOT MIX ASPHALT PLANTS

All HMA facilities must be certified prior to furnishing HMA to MDOT. The certification inspection and documentation will be completed by the Region Traveling Mix Inspector (TMI) in accordance with the following procedure. Certification will be valid for either the current construction season, for permanent plant locations, or for the duration of a temporary plant location.

A. Notification

1. Permanent plant location - The Contractor shall arrange for a certification inspection with the TMI either prior to the start of each construction season or prior to the start of HMA production at that location.

2. Temporary plant location - The Contractor shall arrange for a certification inspection with the TMI prior to HMA production at that location.

B. Inspection

The TMI will notify the Engineer of the inspection arrangements. Either the Engineer or his/her representative may participate in the inspection. The inspection will encompass all components of the HMA facility. The Contractor shall provide copies of all of the required scale certifications and equipment calibrations. The Contractor shall provide evidence that the plant is in compliance with current Michigan Department of Environmental Quality (MDEQ) requirements.

C. HMA Certification

Inspection Report Form - The TMI will complete and provide copies of the inspection check list as appropriate. Equipment deficiencies will be noted and must be corrected before a certification will be issued.

D. De-Certification

Any plant equipment malfunction that directly affects mix quality must be repaired in a timely manner. Failure to do so may result in decertification of that plant. The Engineer receiving HMA mixture from the plant at the time of decertification will receive both verbal and written notification.

The Contractor/Owner will receive immediate written notification of decertification action. The TMI will note what the deficiency is when completing the written notification. The TMI will re-certify the plant when the noted deficiencies have been corrected.

HMA FACILITY

A. All Plants

HMA mixtures shall be produced in continuous, batch, drum mixer or other approved specialized plants. HMA plants shall be in good mechanical condition and any defective plant equipment or malfunction that directly affects the mix quality must be repaired in a timely manner. Failure to do so will result in decertification of that plant. The Contractor shall provide adequate and safe stairways for accessibility to plant operations. Adequate safeguards shall be provided to prevent injury to the personnel from plant components. The mixture sampling platform shall be of the proper height(s) for safe access to the mixture in all hauling units and shall have a safe and adequate stairway. Sampling platforms must comply with Part 45 of General Industries Fall Protection Standards and shall comply with MIOSHA regulations at the time of certification. The placement, structure and adequacy of the sampling platforms shall be approved by the TMI. HMA plants shall meet the requirements specified herein.

1. Aggregate Stockpiles - Aggregate stockpiles shall be constructed and maintained at the plant site. Mix production on any day shall not start until the Contractor has stockpiled, at the plant site, sufficient quantities of all aggregates so as to have uninterrupted production.

2. Asphalt Storage Tanks - Each tank shall identify the grade of binder being stored. Asphalt storage tanks shall be equipped for heating the asphalt binder material at uniform temperatures. There shall be provisions for effective and positive control of the temperature of the asphalt binder within the ranges specified under Table 904-5. Thermometers shall be installed in such locations so as to accurately indicate the temperature of the asphaltic binder material at all times.

3. Aggregate Feed - Power driven belt feeders shall be provided which are capable of supplying an accurately adjustable and continuous flow of each aggregate to the drier. The feeders' rate of flow shall be readily and incrementally adjustable and shall be capable of being secured in any position. The plant shall have a minimum number of cold feed bins to meet mix blend requirements. The plant may not feed two materials from one cold feed bin. There must be a cold feed bin for each material required. The feeders shall be equipped with cut-offs which will automatically stop the operations of the asphalt plant at any time the flow of aggregate is stopped. The aggregate feed system shall be equipped with a mechanical screening device for the removal of oversized material. For HMA base mixtures, the oversize screen shall have a one dimension opening of 1-¾ inches (44 mm). For all other mixes it shall have a one dimension opening ¼ inch (6 mm) larger then the maximum aggregate size in the HMA mixture being produced.

4. Drier - The drier shall be designed so as to continuously heat and dry the aggregates to specification requirements. It shall be equipped with an automatic modulation device to control and maintain the temperature within the specified limits. The drier shall dry the aggregates uniformly. In the event that the drier does not dry the aggregates satisfactorily, the Contractor shall make whatever adjustments may be necessary to give satisfactory results. When excessive moisture is present in the mixture, production shall be discontinued until the necessary corrections are made.

5. Indicating Pyrometer - An indicating pyrometer or other approved thermometric instrument shall be so located as to be in full view of the plant operator and so installed as to indicate the temperature of the material at the discharge end of the drier or mixer. Said instrument shall continuously indicate the temperature of the aggregate at the discharge end of the fine aggregate bin for batch type plants or the mixture temperature at the discharge end of drier drum mixer plants. The sensitivity and efficiency of this instrument shall be such as to record a variation of $\pm$ 7 °F (4 °C) in temperature within one minute. Whenever the thermometric recording instrument does not function properly and does not provide an accurate display of the aggregate temperatures, the Contractor shall provide other satisfactory means for measuring the temperature, except that mixing operations shall be suspended when a properly functioning pyrometer is not provided within 24 hours. Failure to repair is cause for decertification. Recording pyrometer may be used in lieu of the indicating pyrometer.

6. Dust Collectors - Dust collectors shall be provided on all plants. When the plant is equipped to collect baghouse fines in a separate silo, these fines may not be used in subsequent mixtures. Surplus fine aggregate material collected in a silo may not be used in subsequent mixture unless it is a component of an approved mix design.

7. Air Quality Permit - All HMA plants shall be covered by a Michigan Air Pollution control permit. For any portable HMA plant, the Contractor shall obtain a permit-to-install from the Permit Section, Air Quality Division (AQD), of the Michigan Department of Environmental Quality (MDEQ). This permit shall be applied for a minimum of 30 calendar days for plants with an active MDEQ permit (or 60 calendar days for plants not previously permitted in Michigan) prior to the plant being installed. For proposed plant sites in Wayne County, the Contractor shall apply directly to the Wayne County Air Pollution Control Division instead of MDEQ.

8. Mineral Filler Feed (if required by mix design) - Plants furnishing HMA mixture shall be equipped with a mineral filler silo. A method of accurately metering or weighing mineral filler into the mixture shall be provided.

9. Sampling Spigot - The pipeline supplying asphalt binder to the plant shall be equipped with a sampling spigot located in a position between the asphalt binder pump and the point where the asphalt binder enters the mixture. Personnel safety is critical in selecting the position of the sampling spigot.

10. Additive Sampling - A means for sampling any mixture additives will be provided. The sampling point shall be between the source feeder mechanism and the point at which the additive enters the mixture.

11. Interlock System for Aggregate, Mineral Filler or Asphalt Binder - An interlocking system shall be provided to halt production of HMA mixtures if any one of the feed system's aggregate, mineral filler or asphalt binder malfunctions.

12. Scales - Scales for weighing HMA mixtures must meet requirements of Section 109.01G of the current Standard Specifications for Construction.

13. Hot Mix Surge Bins - Surge bins may be used to facilitate an uninterrupted supply of HMA mixture under the following conditions:

a. The HMA mixture shall be maintained at a level above the cone which will ensure that the surge bin will not be emptied during operating periods, except at the end of the day's operations. The bin shall be equipped with a bin level indicator and a horn or buzzer to alert the operator, or an interlock mechanism to prevent the discharge of the mix when the level of the material in the bin has reached a point where insufficient material is in the bin to complete a full load without emptying the bin.

b. Surge bins shall be equipped with a gob hopper at the inlet of the bin. If it is determined that the use of a hot mix surge bin causes segregation, or adversely affects the quality of the mixture, its use shall be discontinued until corrective action has been taken.

c. Surge bins shall have a minimum capacity of at least 100 tons (70 metric tons) or be twice the capacity of the maximum hauling unit.

B. Batch Plants

Batch plants shall accurately proportion aggregate, mineral filler, and asphalt binder by weight.

1. Hot Aggregate Bins - The plant shall have hot aggregate bins of a total capacity of not less than 10 times the weight of the batch being mixed. Each hot aggregate bin shall be equipped with a bin-level indicator which shall indicate when the bin compartment is filled to approximately one-half the bin capacity.

2. Batch Scales - The scales in batch plans shall meet the requirements specified herein:

   a. The scales shall come to rest after the weighing of each ingredient to facilitate the monitoring of the proportioning operations. The scales shall comply with the requirements of the National Bureau of Standards Handbook 44, with the following exceptions and additions:

      i) The value of the minimum graduated interval for scales which have a nominal capacity of less than 5000 pounds (2300 kg) shall not be greater than 5 pounds (2.3 kg), except that the minimum graduated interval for the scale which weighs the asphalt binder shall not be greater than 2 pounds (0.746 kg).

      ii) The value of the minimum graduated interval for scales which have a nominal capacity of 4000 pounds (1866.2 kg) or more shall not be greater than 0. 1 percent of the nominal capacity of the scale.

   b. Accuracy - The tolerance value for all plant scales shall be 2 pounds (0.746 kg) per 825 pounds (373.2 kg) of load or the value of one minimum graduated interval, whichever is greater. At such times as the Engineer may direct, the Contractor shall suspend operations and shall provide such devices and assistance as are required to enable the Engineer to check the accuracy of the scales.

   c. Location - All scales shall be located so they will be in plain view of the operator at all times.

3. Batch Mixer -The plant shall be equipped with a batch mixer of the twin pugmill type. It shall be heat-jacked and equipped with a sufficient number of paddles or blades set in run-around order to produce properly mixed batches of any material required under these specifications. When the clearance between the tip of the paddle blades and mixer liner exceeds one inch, either the blades or liner, or both, shall be replaced to reduce the clearance. Paddle blades reduced by wear in excess of 25 percent in face area from their new condition shall be replaced. The mixer shall be enclosed except for openings necessary to admit materials. It shall be capable of holding and properly mixing at least a 1650 pound (746.48 kg) batch of paving mixture. The mixer paddle shafts shall operate at a speed sufficient to produce satisfactory mixing of the aggregates and the asphalt binder in the specified wet mixing time.

4. Timing Device - The plant shall be equipped with an approved accurate time-lock system to control mixing operations. This system shall lock the weigh box gate after the charging of the mixer, until the closing of the mixer gate at the completion of the cycle. It shall lock the asphalt bucket throughout the dry mix period, and the mixer gate throughout the dry and wet mix periods. The dry mix period is defined as the interval of time between the closing of the weigh box gate and the start of the discharge of the asphalt bucket. The wet mix period is defined as the interval of time from the start of the discharge of the asphalt bucket to the discharge of the pugmill. The timing device shall be enclosed in a suitable case that can be locked.

5. Automatic Proportioning and Cycling Controls - When producing HMA mixtures, batch plants will be required to have systems for automatic batching or proportioning of the various components of the HMA mixtures meeting the following requirements. The automatic proportioning controls shall include equipment for accurately proportioning batches of the various components of the mixture by weight or volume in the specified sequence and for controlling the mixing operations. Adjustable timing devices and other time delay circuits to space the individual component batching and mixing operations will be required, together with the a interlock cut-off circuits necessary to interrupt and stop the automatic cycling of the batching operations whenever and error in weighing occurs or there is a malfunctioning of any other portion of the control system.

   The automatic control for each batching scale system shall be equipped with a device for stopping the automatic cycle in the underweight check position and in the overweight check position for each material so that the tolerance setting may be checked.

   Each dial scale system shall be equipped with a removable dial puller which can be attached to the dial lever system so that the dial can be moved smoothly and slowly through its range to check the settings of the automatic control system. Digital display systems shall be capable of being cycled through a simulated batching operation to check the settings of the automatic control system.

   Operation of the asphalt plant will not be permitted when the automatic proportioning and cycling controls are not operating properly or are not in proper adjustment. Manual operations will only be permitted when a breakdown or malfunction occurs after production has started. Manual operation due to a breakdown or malfunction will be permitted for the remainder of the workday in which the breakdown or malfunction occurs plus one additional work day, provided this method of operation will produce results meeting the specification requirements. If the Contractor has not corrected the malfunction in the allotted time, production of mixture for the project will be stopped until all corrections have been made and the Engineer is assured that the automatic proportioning and cycling controls operate properly.

6. Weight Batch Proportioning - The accuracy required for the equipment weighing the batch components, based on a percentage of the total batch weight, will be to within ± 0.1 percent for the asphalt binder and ± 0.5 percent for each of the other components (aggregate and mineral filler). The weighing system shall be equipped with an interlock to cut off the cycling and weighing operations at any time any individual component weight or the total batch weight exceeds the tolerances specified.

C. Drum Mixer Plants

Drum mixer plants shall be capable of simultaneously heating and mixing the aggregates with a controlled amount of asphalt binder and mineral filler in a rotating cylindrical dryer drum and discharging the mixture into a hot mix surge bin. The plant console shall have displays for both the rate of feed and accumulated weights or amounts of the aggregate, mineral filler, and asphalt binder by weight or volume.

1. Aggregate Feed - The aggregate shall be supplied to the dryer/mixer drum at a continuous, uniform controlled feed rate. The aggregate feed rate shall be measured by an approved electronic weighing device. The weighing device shall also be used to control the rate of flow of asphalt binder and mineral filler (if needed) to the drum mixer. Aggregate feeders shall be used to meet the established job-mix formula. The plant shall have a minimum of number of cold feed bins to meet the mix design blend.

2. Aggregate Moisture Tests - The Contractor shall be responsible for monitoring the moisture content of the raw aggregate.

3. Asphalt Binder Metering - The asphalt binder shall be continuously delivered to the dryer/mixer drum. The rate of feed of the asphalt binder shall be displayed on a totalizer located in the control room. The plant console shall contain provisions for setting the specific gravity and also monitoring temperature of the asphalt binder.

4. Drier/Mixer Drum - The slope of the drum, the flight configuration, and the rate of rotation of the drum shall be maintained and operated in accordance with the manufacturer's recommendations or as approved at time of certification.

5. Calibration - Provisions shall be made for diversion and calibration of the aggregate, mineral filler, asphalt binder and other additives. The plant shall be calibrated by the Contractor prior to the start of the initial production of HMA mixture for the project and at other intervals as directed by the Engineer in accordance with the manufacturer's recommendations. The plant shall be equipped with the following calibration facilities so that the electronic plant controls can be checked and controlled to assure proper proportions.

    a. Aggregate -The Contractor shall provide means for diverting and weighing the aggregate for a time period not to exceed five (5) minutes. The Contractor has the option of running the aggregate into the surge bin during the plant calibration and weighing with a suspended weigh hopper or into a truck and weighing on approved platform scales.

    b. Mineral Filler - When mineral filler is used, the plant shall be equipped with a system to divert the mineral filler into an approved container. The container shall be of a sufficient capacity to hold a calculated weight or volume equal to 4% of the rated capacity of the plant during the calibration test. The Contractor shall have an approved platform scale or

suspended weigh hopper for the weighing of the mineral filler. The calibration will consist of diverting the filler for a period of time not to exceed 5 minutes. The calibration may be done simultaneously with the aggregate and asphalt binder, or separately. If done separately, the aggregate feed control portion of the console will be set at the anticipated production rate during the calibration period.

c. Asphalt Binder - The plant shall be equipped with a tank for the calibration of the asphalt binder feed system. The calibration will consist of diverting the asphalt binder for a time period not to exceed five (5) minutes. The calibration of the asphalt binder my be done simultaneously with the aggregate or may be done separately. If done separately, the aggregate feed control portion of the console will be set at the anticipated production rate during the calibration period.

d. Additive - When additives are used, the plant shall be equipped with a means of accurately calibrating the additive feed system.

D. Combination/Specialized Plants

Will be inspected and certified on a individual basis based on modification or changes. This will be done with TMI's and Bituminous Field Office staff.

QUALITY CONTROL PLAN

The Contractor shall provide a Quality Control Plan (QCP), which might include the following information:

A. Project

1. Company name, plant location, plant (MDOT) number, plant phone and fax numbers, lab phone and fax numbers, office phone and fax numbers:

2. Sampling plan, aggregate, binder, mixture, etc., will include location, method, frequencies:

3. How the random number will be selected:

4. When and how daily belt samples will be taken:

5. Quality control of aggregate stockpiles including RAP stockpiles:

6. How daily moisture sampling will be done:

7. Signatures and date, Contractor and MDOT:

B. Personnel

1. Name(s), title(s) and telephone number(s) of person(s) responsible for the QCP:

2. Name(s), title(s), telephone number(s) qualification and certification number(s) of qualified employee(s) performing sampling, testing and inspection:

3. Name(s), title(s) and telephone number(s) of employee(s) work under the supervision of the qualified employee(s):

4. List the duties, responsibility, accountability and authority of the above employee(s):

C. Documentation

1. Contractor may use MDOT forms:

2. When not using MDOT forms Contractor must use forms approved by the Project Engineer:

3. Quality control charts must be approved by the project Engineer:

4. Contractor will include examples of all non- MDOT forms and control charts to be used:

D. Quality Control

1. How you plan to control the quality of the mixtures being produced:

2. If out of tolerance how this will be corrected:

SECTION 3: HMA QC/QA PROCEDURES FOR FIELD TESTING

PRE-PRODUCTION MEETING FOR

C. S. _____ J. N. _____ DATE _____

HMA Mixture and Pavement Density Special Provision dated _____

Plant Mixed HMA Mixtures Special Provision dated _____

PROJECT LOCATION _____

CONTACT PEOPLE AND ATTENDEES: (Attach additional pages as necessary)

M.D.O.T.: _____ TELE. # _____

FAX # _____

M.D.O.T.: _____ TELE. # _____

FAX # _____

CONTRACTOR: _____ TELE. # _____

FAX # _____

CONTRACTOR: _____ TELE. # _____

FAX # _____

T.M.I.: _____ TELE. # _____

FAX # _____

_____ TELE. # _____

FAX # _____

_____ TELE. # _____

FAX # _____

GUIDELINE FOR PRE-PRODUCTION MEETING (PPM)
FOR INFORMATION AND DISCUSSION ***ONLY***
ITEMS MAY BE CHANGED, ADDED OR DELETED FROM THIS LIST

1. **General Information.** The topics and details listed here should be discussed at the preproduction meeting

   The Contractor shall certify in writing that the materials used in the mixture are from the same source as the materials used in developing the HMA mixture design.

   Submittal of Contractor's Quality Control Plans (QCP) to Engineer (Plant Certification and Project).

   Status of mix designs for the project.

   Test strip designs and requirements (if used).

   Does the Contractor anticipate doing a trial run? All mixes? When? Testing frequency? Tons?

2. **Sampling Frequency and Reporting Requirements**

   Sampling includes, but is not limited to; Aggregate, Asphalt Binder, HMA Mixture (loose and compacted). The Engineer will assure that samples are taken according to approved specifications and methods.

   The Contractor and MDOT will be responsible for obtaining all samples as per specification.

   Discuss how the Contractor and MDOT will conduct random sampling. (reference Materials Quality Assurance Manual Section A-12).

   Written sampling plan must be part of Quality Control Plan. All random sampling tonnage values and core locations must be recorded.

   2.1 Aggregate (Blended)

   A minimum of one blended aggregate sample will be collected per production day. One-half of the daily sample should be placed in a canvas bag, identified and given to the Engineer.

   2.2 HMA Mixture (Loose)

   Minimum of three sublots shall be sampled for any one mixture type. Testing will be agreed upon prior to start of production.

   One sample will be collected from each sublot of mixture. Sublots may vary in size up to 1500 tons. Initial sublot size for each mix will be _____ tons.

All test results for the initial lot for each mix must be given to the Engineer prior to any further production of each mix, unless prior approval is received from the Engineer.

Adequate size samples must be taken to provide sufficient quantity for testing as per specification.

Samples shall be identified (identification shall include mix type, temperature, random tonnage, date, time, *lot/sublot represented* and whether the sample is for the Contractor, MDOT or Referee).

Review what is/is not included in quality control and quality assurance pay items.

2.3 Additional Samples

HMA mixture (in addition to the sublot sample), asphalt cement and mineral filler samples are to be taken by the Contractor, identified and given to the Engineer who is then responsible for MDOT identifications and delivery to C&T Lab.

2.4 HMA Mixture (Compacted)

Four 6-inch (150 mm) cores per sublot.

Location of cores randomly selected and marked by P.E.

Only one core per location; to be taken after final rolling and within 24 hours of placement.

Core thickness measured when taken and before sawing.

Information and record cores. Labeling, sawing and P.E. possession.

No cores may be taken from hand patching areas or commercial / private driveways.

Damaged or non-representative cores will be evaluated by P.E. before transporting to lab.

Core holes to be filled with hot mixture and thoroughly compacted as part of the coring operation. Compaction method to be agreed upon prior to production.

Flag control / traffic control for coring.

3. Contractor Quality Control Testing

Quality control testing will be as outlined in the QCP. The following shall be considered as the minimum.

3.1 Aggregate

Testing and testing intervals as agreed upon with the Engineer. Testing may include gradation, crush, deleterious and fine aggregate angularity.

3.2 HMA Mixture (Loose)

Testing frequency is once per sublot
Test for theoretical maximum density, bulk density, calculated air voids, calculated voids in mineral aggregate and composition of mixture.

4. Quality Control Tolerances

See Special Provision for quality control tolerances.

Discuss what happens when tolerances are exceeded and reasons production must stop; when P.E. is to be notified; and what happens when this does not occur.

5. Quality Assurance Testing

5.1 Projects with HMA Mixture and Pavement Density Special Provision

MDOT to use the same option as the Contractor. Testing will be done at the field Laboratory.

The Engineer shall perform and report the results within two work days following completion of the lot. If the Engineer is unable to provide verification test results within two workdays, the Contractor's test results will be used for acceptance and payment <u>if they are verified</u>.

Cores minimum thickness requirement before sawing.

Testing of cores by MDOT will be done within two work days of receiving the core samples.

Test reports and control charts formats must be approved by the P.E. before production starts *and should follow MDOT formats.*

Daily Reports - Contractor Daily Report & plotted control charts.

Project Summation - Control Charts (individual test results, lot averages, running average) and test data tabulation (sublot data, lot averages, project average, standard deviation and lots with price adjustments).

5.2 Small Tonnage Projects

Three equal sublots. Randomly selected samples within each sublot.

One sample split for MDOT testing. Verification tolerance will apply to MDOT tests.

Pavement density by MDOT Nuclear Density Gauge using the TMD from the JMF. Six locations will be randomly located and tested.

Contractor can choose to core but this decision must be made, in writing, before production starts. No payment for coring.

5.3 Projects without HMA Mixture and Pavement Density Special Provision

Uniformity tolerance applies. Discuss procedures when tolerances exceed Range 1 but do not exceed Range 2.

Rejected Mixture. Review process when parameters exceed Range 2 twice or Range 1 three times.

6. Measurement and Payment

Measured in tons.

Price Adjustments to Mixtures and to Asphalt Binders.

7. Review Special Provisions

CHECKLIST FOR
REDUCTION OF SAMPLE PROCEDURE

Refer to these test methods and procedures. **Newest MTM should be used**.

MTM 107 Sampling Aggregates
MTM 313 Sampling Bituminous (HMA) Paving Mixtures
MTM 324 Sampling Bituminous (HMA) Materials from Behind the Lay Down Machine
Materials Quality Assurance Manual Section A-12

1. The sublot sample to be tested shall be selected by the project Engineer following the random number selection process described in Section A-12 of the Materials Quality Assurance Manual.

2. The entire sample shall be mixed and split on a clean, smooth non-porous surfaced approved splitting table. The table shall be heated when necessary.

3. The sample will be two opposite sides of the randomly selected sample.

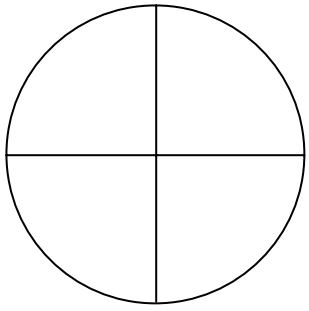
4. The following sample sizes are intended to be a **guide** for the splitting procedure. The weights are to be adjusted based on the tests being conducted. (See MDOT procedure for each test).

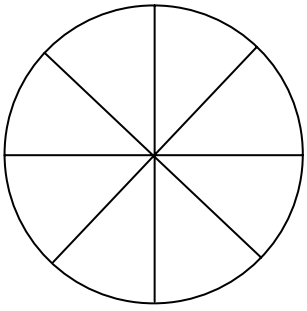
Test Method	Sample Size
Marshall Density	3600 - 3750 grams
Superpave Gyratory Compactor Density	sufficient for two 115 mm specimens
Theoretical Maximum Density	2000 - 2500 grams
Centrifuge Extraction	1200 - 1600 grams
Vacuum Extraction	2000 - 4000 grams
Ignition Method	2000 grams maximum

(Coordinate the anticipated sample weights and Independent Assurance Sampling (IAS) needs prior to each sample).

5. Retain all excess material until satisfactory completion of the testing.

Note: Quartering may be done as many times as needed to get the required amount of material to complete the tests required. It is important that you always use the opposite sides for each test.





Examples of Sample Splitting
Opposites ¼ or 1/8 (2 examples)

CHECKLIST FOR
THEORETICAL MAXIMUM DENSITY DETERMINATION

Refer to these test methods and procedures. **Newest MTM should be used**.

MTM 314 Theoretical Maximum Specific Gravity and Density of Bituminous (HMA) Paving Mixtures

CHECKLIST FOR
CALIBRATION OF PYCNOMETER WITHOUT COVER

1. The pycnometer shall be calibrated a minimum of once per week or more often if needed.
2. Weigh the dry, empty pycnometer (bowl without cover), to the closest 0.1 gram. Record the weight on the calibration worksheet (a).
3. Repeat step 1 until there are three (3) consecutive weights within ± 0.1 gram of each other. Average the three weights.
4. Immerse pycnometer in water bath, control temperature at 77 °F ± 1.8 °F (25 °C ± 1 °C) without the cover.
5. Allow pycnometer to reach bath temperature (3-5 minutes).
6. Weigh pycnometer in water and record weight on calibration worksheet (b).
7. Repeat steps 4-6 until there are three consecutive weights within ± 0.3 grams of each other.
8. Average the three weights in step 7.
9. Record pycnometer identification number on calibration sheet. Preserve information for future reference.
10. Clean and dry the bowl and cover to prevent accumulation of material that would affect the volume or weight of the pycnometer.

CHECKLIST FOR
THEORETICAL MAXIMUM DENSITY DETERMINATION PROCEDURE WITHOUT COVER

1. Place quartered sample [4.4 to 5.5 pound (2000 to 2500 gm)] on large clean tray and spread out as thin as possible. Allow to cool to ambient air temperature 72 °F (22 °C.) Using a fan will expedite this step of the procedure.

2. Manually separate mixture particles as mix is cooling. Coarse aggregate should be no larger than single stone particle size, and the fine aggregate portion should be no larger than 1/4 inch (6.350 mm) size particles.

3. Select a previously calibrated pycnometer and verify the calibrated dry weight. Carefully transfer the separated mixture sample into the calibrated pycnometer bowl.

4. Weigh the sample and pycnometer (minus the cover) to the closest 0.1g. Record the weight on the work sheet.

5. Pour enough water [use the 77 °F (25 °C) water from bath] to cover the sample and submerge it at least 1 inch (25mm) under the surface of the water. The water level should not be allowed to go higher than within 1 inch (25mm) of the top of the pycnometer bowl.

6. Place the transparent cover with vacuum gauge (cover should be attached to vacuum pump and to the manometer) on the pycnometer and place pycnometer on vibrating table and start pump and vibrating table.

7. Observe manometer. After the mercury level stabilizes (the absolute vacuum should reach 30.0 mm hg. or less), allow the pump to run for a fifteen (15) minute time period on the vibrating table.

8. Stop the vibrating table and vacuum pump. Slowly open the bleeder valve to release the vacuum and remove the transparent cover.

9. Place the pycnometer (without cover) in the 77 °F ± 1.8 °F (25 °C ± 1 °C) water bath (be very careful to not allow any air to re-enter the sample). The pycnometer and sample should remain in the bath for a ten (10) ± 1 minute time period.

10. Weigh pycnometer and material completely under water without cover.

11. Record weight on work sheet.

12. Complete the necessary calculations as indicated.

    Note: The weight of pycnometer in air and under water does not include cover.

BULK DENSITY PROCEDURE

CHECKLIST FOR
MARSHALL DENSITY AND PERCENT AIR VOIDS PROCEDURE

The desired volume of the Marshall specimen is 515 cc ± 8 cc. This is approximately 2½ inches (63.5 mm) in height of compacted specimen or approximately 1200-1250 gms of loose mixture.

Refer to Michigan Test Method 315 and procedures. **Newest MTM should be used**.

1. Place the three quartered samples in 32 ounce (946 mL) ointment cans and cover.

2. Place containers, with sample, in oven. Oven temperature may not exceed upper limit of mixing temperature range.

3. Allow samples to heat to the compaction temperature identified on the JMF, Form 1911.

4. Place three Marshall molds, hand tools, and equipment in oven to allow them to reach compaction temperature.

5. Place Marshall hammer assembly on an electric hot plate (in close proximity to the Marshall pedestal) and allow to heat up to compaction temperature (280 °F ± 5 °F {138 °C ± -15 °C}).

   Note: Steps 6 – 14 should be completed as quickly as possible to reduce the potential for temperature loss before compaction is completed.

6. Verify the samples and the molds have reached compaction temperature.

7. Remove a mold from the oven and place a paper disk on base plate of mold. Set the mold and collar sections on top of the base plate over the paper.

8. Remove a sample from the oven and carefully transfer it to the mold using a 4 inch Marshall funnel. With a spatula, rod the mixture in the mold (15 times around the perimeter and 10 times through the interior portion), and then taper the top perimeter portion of the specimen.

9. Transfer mold and sample to Marshall pedestal and put hold down device in place. Place a paper on top of sample.

10. Place Marshall hammer assembly in place. Using the handle-holding device, secure the hammer assembly in the vertical position as close as possible to being perpendicular to the base.

11. Lift the moveable weight portion of the hammer assembly to the top and release it (this is considered one blow of the hammer). Repeat this procedure to complete a fifty (50) blow cycle. The blows should be cycled at approximately one per second.

12. Remove the hammer assembly from the mold and place it back on the hot plate.

13. Remove top portion of Marshall mold assembly. Turn partially compacted Marshall specimen (lower portion of assembly) over and re-position on base (it may be necessary to replace papers). Replace top portion of Marshall mold. Specimen shall be uniformly seated on the base plate.

14. Repeat steps 10 through 13.

15. Remove entire mold assembly with sample from pedestal and transfer to work counter.

16. Separate top collar and base from assembly. Remove papers, label specimen and place mold and specimen on edge and allow to air cool to ambient temperature. A fan may be used to speed cooling.

17. Repeat steps 7 through 16 for the remaining two samples.

18. Clean the equipment that has been used (hammer assembly, mold parts, etc.).

19. When the Marshall specimens have reached ambient temperature, remove them from the molds using the Marshall specimen extruder.

20. Carefully scrape the top and bottom edges of the specimens and examine (to assure there are no loose particles of mix clinging to them).

    Note: All weights shall be recorded to the nearest 0.1 gm.

21. Place the first Marshall specimen on top of the scale. Read and record the dry weight of the specimen on a Marshall density worksheet.

22. Repeat step 21 for the remaining two Marshall specimens.

23. Submerge the three Marshall specimens in the water bath under the scale for a 3 to 5 minute soaking period. Make sure to remove all air bubbles from outside of specimens. (Water bath should be maintained at 77 °F ± 1.8 °F (25 °C ± 1 °C). If the temperature of the specimen differs from the temperature of the water bath by more than 2 °C, the specimen shall be immersed in the water bath for 10 to 15 minutes instead of 3 to 5 minutes.

24. Tare the scale and place the first Marshall in the suspended weighing basket under this scale. Allow the scale to settle. Read and record the weight of the specimen in water.

25. Remove the specimen from the bath and place on a damp towel and quickly blot all surfaces to obtain a saturated surface dry condition.

26. Place the specimen on the scale, read and record the weight of the saturated surface dried specimen.

27. Repeat steps 24 through 26 for the remaining two specimens.

28. Complete the required calculations for each of the specimens.

29. Average the three Marshall densities.

30. Complete the calculation.

Note: Instead of a hand-operated hammer, a mechanically operated hammer may be used provided it has been calibrated to give results comparable with the hand-operated hammer. The hand-operated hammer will be the standard hammer. Calibration shall be accomplished by increasing/decreasing the number of blows. (Weight of the hammer shall be maintained within 10 ± 0.02 pounds with a freefall of 18 ± 0.06 inches).

CHECKLIST FOR
GYRATORY COMPACTOR

Referenced Document AASHTO T312-03, Section 7.

The desired height of the gyratory specimen is 115mm ± 3mm. Approximately 4900 ± grams.

1. Place gyratory molds in oven set at compaction temperature identified on the JMF, Form 1911.

2. Place the two quartered samples into separate mold loading devices* and place into oven to bring samples to compaction temperature as stated on JMF. Oven temperature may not exceed upper limit of mixing temperature range.

3. As soon as mold and sample have reached compaction temperature, remove mold from oven. Make sure bottom plate is properly seated in the bottom of mold and place paper disc in bottom of mold.

4. Transfer the material directly from the separate mold loading device* to the mold and in one continuous motion to maintain a homogeneous mass.

5. Level off sample, place paper disc on top and place the top plate over the paper disc making sure the beveled side of plate is up.

6. Place mold with sample into the gyratory compactor as per the manufacturer's requirements. Verify the machine settings are correct for mold size, angle, pressure and number of gyrations.

7. Start the gyratory compactor.

8. When the gyratory compactor stops, extrude sample or remove mold, as applicable. The specimen can be extruded from the mold immediately after compaction for most HMA. However, a cooling period of 5 - 10 minutes in front of a fan may be necessary before extruding some specimens to ensure the specimens are not damaged. Remove paper disc from sample after a short period of time using care to avoid damage to specimen.

9. Allow samples to reach ambient temperature. Then carefully clean top and bottom of all loose particles and label samples.

10. Refer to Michigan Test Method 315 (Bulk Specific Gravity and Density of Compacted HMA Mixtures Using Saturated Surface-Dry Specimens. **Newest version should be used**.

***It is recommended to use this device or equivalent. The purpose of the device is to allow the mold to be filled in one continuous motion to maintain a homogeneous mass.**

EXTRACTION PROCEDURES

CHECKLIST FOR
HMA MIXTURE ANALYSIS CENTRIFUGE EXTRACTION

CARE-ACCURACY-PRECISION

1. Obtain a representative sample of HMA mixture (1200-1600 grams).

   a. Sample size may be adjusted depending on capacity of extractor to be used.

   b. If splitting the sample to run two (2) extractions, combine the weights from both extractions before calculating percentages.

2. Sample is dried to a constant weight. The sample is allowed to cool, then carefully weighed to closest 0.1 gram and weight recorded on worksheet.

3. Extractor bowl is set on stable base, e.g. ac sample can.

4. Sample is transferred to extractor bowl (care must be taken to ensure no part of the sample is lost during the transfer.) Extractor bowl is then placed in extractor.

5. Solvent is poured over sample until it is covered (note volume of solvent required).

6. Sample is prodded and stirred with spatula for a minimum of 10 minutes.

7. Spatula blade is cleaned with solvent into bowl.

8. Filter is put in place.

9. Bowl cover is placed in position and secured with lock nut (finger tight).

10. Extractor is started and pencil lead stream of effluent (solvent and asphalt) established.

11. When effluent flow slows to a dripping rate, the extractor is shut down and bowl rotation stopped. Care must be taken to ensure that all the effluent has been extracted before recharging.

12. Extractor bowl is recharged with solvent (same amount of solvent as used in step no. 5).

13. Agitate extractor bowl for a minimum of 2 minutes.

14. Extractor is started and a pencil lead stream established.

15. Solvent wash cycles (steps 11 thru 13) should be repeated until effluent is relatively free of asphalt (slightly straw colored).

16. Clear water (volume equivalent to that of the solvent) is then added to sample.

17. Agitate extractor bowl for a minimum of 2 minutes.

18. Extractor is started and a pencil lead stream established.

19. Clear water wash cycles (steps 16 thru 18) are repeated until effluent is relatively clear (initial washes will have a milky appearance).

20. Sample may be given high rpm spin cycle at conclusion of final water wash cycle.

21. Extractor bowl, with sample, is removed from the extractor and placed on a stable base; e.g. ac sample can.

22. Remove lock nut and cover from bowl. Examine cover for residual dust. If dust is present brush it back into sample.

23. Carefully remove filter, fold, and transfer to sample pan.

24. Aggregate is carefully transferred to sample pan (narrow bladed spatula may be used to scrape aggregate loose from extractor bowl).

25. Remaining aggregate is flushed from bowl with clear water, or air dried and then brushed into sample pan.

26. Folded filter is placed on sample of extracted aggregate in the sample pan.

27. Sample is placed on burner to dry.

28. When aggregate and filter are dried to a constant weight, ignite filter and burn completely to an ash.

29. Sample is removed from hot plate and allowed to cool.

30. Sample is weighed to closest 0.1 gram and weight recorded on worksheet.

31. Sample carefully returned to sample pan.

32. Liquid detergent and water added to sample.

33. Sample is washed repeatedly, with each wash being decanted over No. 200 (75 μm) sieve. A No. 16 (1.18 mm) protection sieve should be over the wash sieve until water appears clear.

34. Material retained on No. 200 (75 μm) sieve is flushed with a small amount of clear water back into sample pan.

35. Sample is placed on burner to dry to a constant weight.

36. Sample is then removed from heat and allowed to cool.

37. Sample is weighed to closest 0.1 gram.

38. Weight is recorded on worksheet.

39. Sample is placed in a set of sieves and shaken for 10 minutes.

40. Material retained in each sieve is weighed. Weight is recorded on worksheet.

41. Aggregate retained on and above the No. 4 (4.75 mm) sieve is kept separate to use for crush content.

42. Material retained on and above No. 4 (4.75 mm) - material is weighed and weight recorded on worksheet and is picked for crushed particles.

43. Crushed particles are weighed and weight recorded.

44. All calculations completed (see notes at conclusion of checklist).

45. Save sample until test results are compared to mix specifications and JMF.

46. Equipment is cleaned and put back in organized manner.

<<<< NOTES >>>>

a. Weights retained, when totaled, should be equal to the weight of dry extracted aggregate.

b. Fraction retained should total 100 %.

c. Cumulative fraction passing No. 200 (75 µm) should be the same as P. 200 (75µm) in the fraction retained column and also in the P. 200 (75 µm) in agg. of HMA column.

d. Percent of crushed particles should be noted on work sheet.

e. Dispose asphalt/solvent mixture and water/solvent mixture as directed by the Traveling Mix Inspector (TMI) or by the Contractor.

CHECKLIST FOR
HMA MIXTURE ANALYSIS VACUUM EXTRACTION

CARE-ACCURACY-PRECISION

1. Based on the following table, dry a sufficient amount of diatomaceous earth (de):

JMF % P. 200 IN MIXTURE	GRAMS OF DRY DE
0.0 % - 2.0 %	100 grams
2.0 % - 4.0 %	150 grams
4.0 % - 6.0 %	200 grams
6.0 % - 8.0 %	250 grams

2. Dry two filter papers in the oven at 290 °F (143 °C) for a minimum of one hour.

3. Number and weigh the filters individually. Record the weights on the worksheet (see note iii).

4. Place a dry filter and the recommended grams of de (from the above table) on the extractor filter support plate. Record the combined weights on the worksheet.

5. Tighten the wing nuts on the funnel ring so as to prevent leakage under the ring and retain an air gap under the filter support.

6. Pour approximately ½ gallon (2000 mL) of the solvent into the funnel ring. Using a spoon, manually swirl the combined solvent and de.

7. Allow the de to settle into a uniform layer on top of the filter. Start the vacuum pump and vacuum off the clean solvent into the 1-1/2 gallon (5000 mL) flask.

8. Place the 12 inch (304.8 mm) diameter No. 200 (75 μm) sieve on top of the funnel ring.

9. Obtain a representative sample of the asphalt mixture to be tested. (Sample weight should be between 2000 and 4000 grams). Sample is heated and dried to a constant weight.

10. Place the cooled sample in tarred large stainless steel bowl. Weigh the sample to the nearest 0.1 gram. Record the weight on the worksheet.

11. Pour enough solvent over the sample to completely cover. Stir the sample and solvent with a spoon to dissolve the asphalt. Stir for a minimum of five minutes.

12. When stirring has stopped, allow the materials to settle out.

13. Start the vacuum pump. Slowly decant the effluent over the surface of the 12 inch (304.8 mm) No. 200 (75 μm) sieve sitting on top of the funnel ring.

14. With the vacuum pump running, repeat steps 11 through 13 until effluent is a light amber color. This will complete the solvent washes.

15. Pour enough water (hot water works best) over the solvent washed sample to completely cover it. Stir the sample to emulsify the residual solvent (the water should turn a milky color).

16. Using the same procedure as the solvent, decant the water over the No. 200 (75 μm) sieve.

17. Repeat steps 15 and 16 until the wash water is free of dust and/or emulsified solvent (water should be nearly clear). A drop of liquid detergent may be added to the third and fourth wash to aid in releasing the dust.

18. Allow the vacuum to pull all the water from the filter surface. Wash the P 200 (75 μm) material from the P 200 (75 μm) screen into the extracted aggregate. Aggregate is now ready to dry.

19. Place the extracted aggregate in a pan and place on a hot plate to dry to a constant weight.

20. Scrape the de dust from the edge of the extractor toward the center breaking all the de dust free from the paper filter. Remove the funnel ring from the extractor. Place the filter paper and de dust in a pan, separate from the aggregate, and dry at a temperature of 350 °F (177 °C) or more. When dry, weigh the filter paper and dust (see note III) to the nearest 0.1 gram and record the weight on the worksheet.

21. When the extracted aggregate is dry and cool, weigh and record the weight on the worksheet. Complete the sieve analysis as per centrifuge extraction procedures.

22. Complete all computations on worksheet.

<<<< NOTES >>>>

a. It may be necessary to scrape the dust laden top layer of de toward the center to allow the water to pass more freely.

b. Dispose of asphalt/solvent mixture and water/solvent mixture as directed by the traveling mix inspector (TMI) or by the Contractor.

c. If burning filter, do not weigh.

CHECKLIST FOR
IGNITION FURNACE

Reference and applicable documents **Newest MTM should be used.**

MTM 319 - Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method.

1. Sample size shall be equal to calibration size ± 10 grams if calibration method I is used. Sample size shall be 100 ± 10 grams greater than the calibration sample if calibration method ii is used. Samples shall not exceed 2000 grams. If larger size samples are needed, the test sample may be divided into suitable increments, tested, and the results appropriately combined for calculation of asphalt content.

2. Preheat the ignition furnace to 900 °F ± 9 °F (482 °C ± 5 °C), or to approved test temperature. If method ii was used for calibration, use temperature 104 °F (40 °C) less than that used for calibration.

3. Input the correction factor for the specific mix to be tested into the ignition furnace controller, and record on worksheet.

4. Weigh and record the weight of the sample baskets and catch pan (with guards in place).

5. Distribute approximately equal portions of the sample among the baskets, starting with the bottom basket in the catch pan. Use a spatula or trowel to level the sample, taking care to keep material away from the edges of the basket. Re-nest baskets in the catch pan as the sample is being distributed. Replace cover and guard on basket assembly.

6. Weigh and record the sample, baskets, catch pan and basket guards. Calculate and record the initial weight of the sample (total weight of the sample basket assembly).

7. Input the initial weight of the sample in whole grams into ignition furnace controller. Verify that correct weight has been entered.

8. Open the chamber door. Using the sample transfer device, place the baskets with the sample into the furnace. Close the chamber door and verify that the sample weight (including the baskets) displayed on the furnace's scale equals the total weight recorded within ± 5 grams. Differences greater than 5 grams or failure of the furnace balance to stabilize may indicate that the sample baskets are contacting the furnace wall and will invalidate the test. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

9. Allow the test to continue until the stable light and audible stable indicator signify that the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

10. Open the chamber door. Using the sample transfer device, remove the baskets with the sample. Place hot sample and basket assembly on a heat proof surface and place the protective cage over it. Allow to cool to room temperature.

11. Empty the contents of the baskets into a pan or bowl. Use a small wire sieve brush to ensure that all fines are removed from the baskets.

12. Perform the sieve analysis.

13. Attach a copy of original printed out test results to worksheet.

CHECKLIST FOR
SIEVE ANALYSIS

Refer to these test methods and procedures. **Newest MTM should be used**.

MTM 108	MTM 109	MTM 110
MTM 117	MTM 118	MTM 311

1. Sample is placed on burner to dry.
2. Sample is removed from hot plate and allowed to cool.
3. Sample is weighed to closest 0.1 gram and weight recorded on worksheet.
4. Sample carefully returned to sample pan.
5. Liquid detergent and water are added to sample. (Detergent not required for ignition sample).
6. Sample is washed repeatedly, with each wash being decanted over No. 200 (75 μm) sieve (a No. 16 (1.18 mm) protection sieve should be over the wash sieve) until water appears clear.
7. Material retained on No. 200 (75 μm) sieve is flushed with a small amount of clear water back into sample pan.
8. Sample is placed on burner to dry to a constant weight.
9. Sample is then removed from heat and allowed to cool.
10. Sample is weighed to closest 0. 1 gram.
11. Weight is recorded on worksheet.
12. Sample is placed in a set of sieves and shaken for 10 minutes.
13. Material retained in each sieve is weighed. Weight is recorded on worksheet.
14. Aggregate retained on and above the No. 4 (4.75 mm) sieve is kept separate to use for crush content.
15. Material retained on and above No. 4 (4.75 mm), materials is weighed and weight recorded on worksheet and is picked for crushed particles.
16. Crushed particles are weighed and weight recorded.
17. All calculations are completed. (See notes at conclusion of checklist).
18. Save sample until test results are compared to mix specifications and JMF.
19. Equipment is cleaned and put back in organized manner.

FORMULAS FOR CALCULATING ASPHALT AND VMA

1. Calculating Asphalt Content

$$Pb = \frac{100 \text{ x } Gb \text{ x } (Gse - Gmm)}{Gmm \text{ x } (Gse - Gb)}$$

Where:

Pb - Asphalt Content (%)

Gb - Specific Gravity of Asphalt Cement

Gse - Effective Specific Gravity of Aggregate (From Mix Design)

Gmm - Maximum Theoretical Specific Gravity of Mixture

2. Calculating Voids in the Mineral Aggregate (GSE)

$$VMA = 100 - \left(\frac{Gmb \text{ x } (100 - Pb)}{Gse} \right)$$

Where:

VMA - Voids in the Mineral Aggregate (%)

Gmb - Bulk Specific Gravity of Compacted Marshall Specimen

Pb - Asphalt Content (%) Calculated FROM FORMULA, NOT EXTRACTED VALUE

Gse - Effective Specific Gravity of Aggregate (from 1911)

3. Calculating Voids in the Mineral Aggregate (GSB)

$$VMA = 100 - \left(\frac{Gmb \text{ x } (100 - Pb)}{Gsb} \right)$$

Where:

VMA - Voids in the Mineral Aggregate (%)

Gmb - Bulk Specific Gravity of Compacted Mixture

Pb - Asphalt Content (%) Calculated FROM FORMULA, NOT EXTRACTED VALUE

Gsb - Bulk Specific Gravity of Total Aggregate (From 1911)

PROCEDURE FOR DETERMINING PAVEMENT DENSITY

CHECKLIST FOR DETERMINING PAVEMENT DENSITY (CORES)

1. Check for proper preparation of cores for testing.

   a. Identification
      - Mixture type i.e. wearing, base, etc.
      - Lot No., Sublot No.
      - Core No.

   b. Condition
      - Bottom surface must be sawed.
      - Proper handling and storage of core samples is critical for accurate density results. This is a Contractor responsibility.
      - Any loose material should be removed from core samples before weighing.

2. Check the temperature of the water in the water bath under the scale. It should be controlled at 77 °F ± 1.8 °F (25 °C ± 1 °C).

3. Place core in bath for a three to five minutes time period. Make sure to remove all air bubbles from outside of specimens. If the temperature of the cores differs from the water temperature by more than 2 °F (1 °C) the cores shall be immersed for 10 to 15 minutes.

4. Zero the scale and place a core in the suspended basket in the water bath.

5. Allow the scale to settle and read and record the weight of the core (in water) on line E of the worksheet.

6. Remove the core from the bath and using a damp cloth, with a blotting motion, surface dry the specimen.

7. Zero the scale. Place the surface dried core on the scale pan. Read and record the weight of the specimen in air.

8. Place the core in a tared pan (pie plate) in oven. Thoroughly dry the specimens to constant mass at 230 °F ± 9 °F (110 °C ± 5 °C.) Note: a 15 to 24 hour time period is usually adequate.

9. Remove the core from the oven and allow to cool to room temperature.

10. Place the core and pan on the scale and weigh and record the total weight.

11. Subtract the pan weight from the total weight to determine the oven dry weight of the core.

12. Determine the volume of the core specimen.

13. Determine the specific gravity of the core specimen, G_{mb}.

14. Using the verified maximum theoretical specific gravity, G_{mm} of the mixture (check for correct sublot), determine the percent compaction of the mixture.

15. Repeat steps 1 thru 14 as necessary to determine the percent compaction of each of the cores.

ROUNDING OFF METHOD

1. Rounding of test data and test results used for the acceptance and payment of HMA mixtures.

2. Rounding procedure of ASTM E29-93a sections 4.3, 6.4 and 6.5 shall apply. This procedure is restated here.

3. When the figure next beyond the last place to be retained is less than 5, retain unchanged the figure in the last place retained.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.2344 =	93.2	93.23	93.234

4. When the figure next beyond the last place to be retained is greater than 5, increase by one the figure in the last place retained.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.2678 =	93.3	93.27	93.268

5. When the figure next beyond the last place to be retained is 5, increase by one the figure in the last place retained if it is odd; leave the figure unchanged if it is even.

EXAMPLES:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.3365 =	93.3	93.34	93.336
	93.3375 =	93.3	93.34	93.338

6. The rounding off value should be obtained in one step by direct rounding off of the most precise value available and not in two or more steps of successive roundings.

7. Most Precise Value Available:

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	2.9466	2.9	2.95	2.947

Note: 2.946 rounded to the nearest 0.1 is 2.9; do NOT round first to 2.95 and then to 3.0.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	3.5549	3.6	3.55	3.555

Note: 3.5549 rounded to the nearest 0.01 is 3.55; do NOT round first to 3.555 and then to 3.56.

8. At any time a test method or procedure requires test data or test results to be recorded it must be rounded to the significant place required, ***before being carried forward into further calculations or being compared to specification limits***. Rounded numbers shall be used for any future calculations. Rounding shall be done as above procedure. Figures may be checked for accuracy at any time.

PROCEDURE FOR
ACCEPTANCE SAMPLE REHEATING

The entire sample shall be allowed to cool down to or warm up to ambient temperature before quartering. Reheating shall take place immediately prior to performing the tests, including quartering. Oven temperature may not exceed upper limit of mixing temperature range. Samples shall not be reheated overnight or for extended periods (maximum of 3 hours). The sample to be used for determining Theoretical Maximum Density shall be processed immediately and not returned to the oven.

Note: Lids must be left on samples in buckets during reheating.

CORE HANDLING AND TRANSPORTING PROCEDURE

1. Cores being removed from pavement must be witnessed by owner/agency.

2. Evaluate core for any damage upon removal from pavement.

3. Cores shall be handled carefully as to keep the core in a good condition.

4. Core must be identified and labeled when removed from pavement as follows:

   - Mixture Type, i.e. wearing, base, etc.
   - Sublot No.
   - Core No.

5. Identify the portion of the core to be tested, (top, center, bottom).

6. Core thickness of the mixture material to be tested (appropriate lift) must be measured at the time of removal.

7. Cores shall be placed in a transport container.

8. Cores shall be handled in a safe manner as not to damage cores while transporting from coring site to testing site. The process during transport is to use a standard cooler, and place individual cores vertically (surface side down) in plastic concrete cylinder molds cut to fit the size of the cooler. The temperature inside the cooler containing cores shall not exceed 77 ºF. If ambient temperature is greater than 77 ºF, the cooler shall be cooled with ice. When cores are received at the testing site, they shall be checked for identification, proper paperwork and that they are not damaged.

APPENDIX A - MDOT FORMS

TO BE PLACED IN THIS SECTION BY TESTER

1829	Testing of HMA Mixtures (Calculation Worksheet)
1839	Testing of HMA Mixtures (Vacuum Worksheet)
1878	Testing of HMA Mixtures (TMD and Marshall)
1903	Daily Report of HMA Plant Inspection
1903b	Report of Acceptance Testing
1903c	Daily Report of Contractor's Quality Control Tests
1905	Testing of HMA Mixtures (Centrifuge Worksheet)
1907	MDOT Report of Compacted HMA Mixture Core Density & Percent Compaction
1912	Testing of HMA Mixtures (Ignition Furnace Worksheet)
1923b	Sample Identification (HMA Materials from Project)

APPENDIX B - MICHIGAN TEST METHODS (MTM)

TO BE PLACED IN THIS SECTION BY TESTER

MTM 107	Sampling Aggregates
MTM 108	Materials Finer than No. 200 (75 μM) Sieve in Mineral Washing
MTM 109	Sieve Analysis of Fine, Dense Graded, Open Graded and Coarse Aggregates in the Field
MTM 110	Determining Deleterious and Objectionable Particles in Aggregate
MTM 117	Determining Percentage of Crushed Particles in Aggregates
MTM 118	Measuring Fine Aggregate Angularity
MTM 311	Determining Aggregate Gradation for HMA Mixture
MTM 313	Standard Practice of Sampling HMA Paving Mixtures
MTM 314	Theoretical Maximum Specific Gravity and Density of HMA Paving Mixtures
MTM 315	Bulk Specific Gravity and Density of Compacted HMA Mixtures Using Saturated Surface-dry Specimens
MTM 319	Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method
MTM 324	Sampling HMA Material from Behind the Lay down Machine

APPENDIX C - PROJECT SPECIFICATIONS

TO BE PLACED IN THIS SECTION BY TESTER